Fecal Coliform Bacteria TMDL for Antelope Creek in Richland County, North Dakota

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1.0 INTRODUCTION AND DESCRIPTION OF THE WATERSHED

The Antelope Creek watershed is a 122,923 acre watershed located in Richland County in southeastern North Dakota (Figure 1). Antelope Creek is a tributary of the Wild Rice River and lies within the Level IV Lake Agassiz Plain Ecoregion (48).

Table 1. General Characteristics of the Antelope Creek Watershed.

Legal Name	Antelope Creek
Stream Classification	Class III
Major Drainage Basin	Red River
8-Digit Hydrologic Unit	09020105
Counties	Richland County
Ecoregions	Lake Agassiz Plain (Level III), Glacial Lake Agassiz Basin (Level IV)
Watershed Area (acres)	122,923

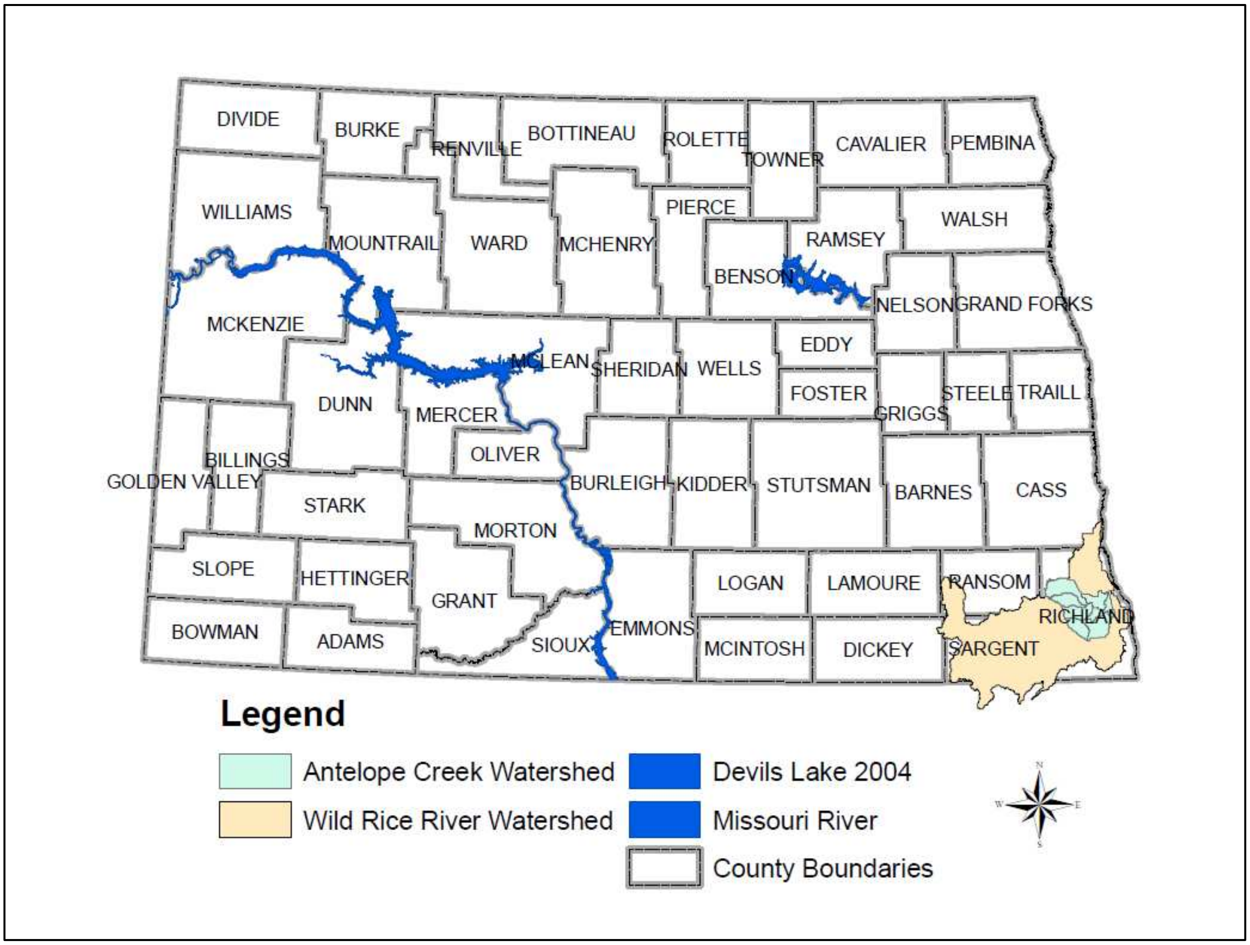

Figure 1. Antelope Creek and Wild Rice River Watershed in North Dakota.

1.1 Clean Water Act Section 303(d) Listing Information

Based on the 2008 Section 303 (d) List of Impaired Waters Needing TMDLs (NDDoH, 2008), the North Dakota Department of Health has identified a 40.73 mile segment (ND-09020105-005-S_00) of Antelope Creek, in Richland County, from its headwaters downstream to its confluence with the Wild Rice River as fully supporting, but threatened for recreational uses. The impairment is due to fecal coliform bacteria (Table 2).

Table 2. Antelope Creek Section 303(d) Listing Information for Assessment Unit ID ND-09020105-005-S_00 (NDDoH, 2008).

Assessment Unit ID	ND-09020105-005-S_00
Waterbody Description	Antelope Creek, in Richland County, from its headwaters downstream to its confluence with the Wild Rice River
Size	40.73 miles
Designated Use	Recreation
Use Support	Fully Supporting, but Threatened
Impairment	Fecal Coliform Bacteria
TMDL Priority	High

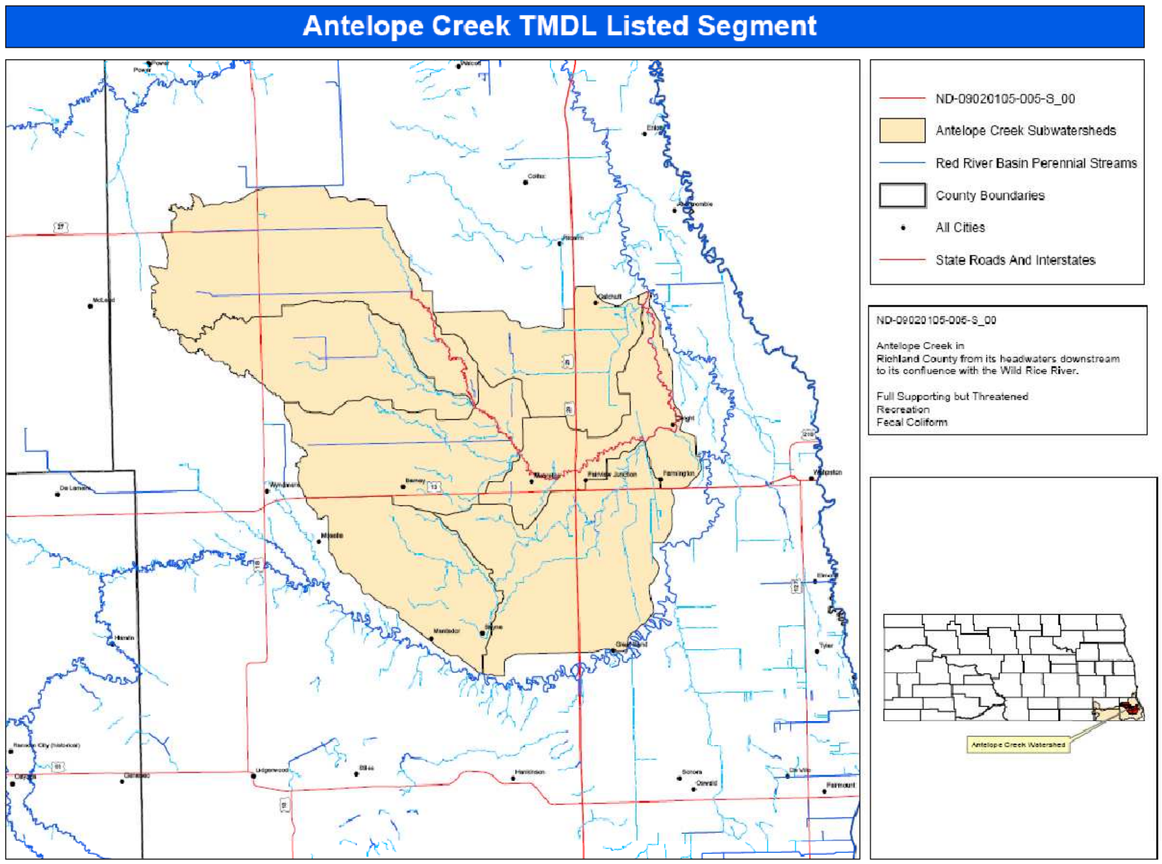

Figure 2. Antelope Creek TMDL Listed Segment.

1.2 Topography

Approximately sixty percent of the associated subwatersheds for the Section 303(d) listed segments highlighted in this TMDL are within the Level IV Lake Agassiz Plain ecoregion (48a) with the remaining forty percent located in the Sand Deltas and Beach Ridges ecoregion (48b) Figure 3. The Lake Agassiz Plain ecoregion (48a) is comprised of thick beds of glacial drift overlain by silt and clay lacustrine deposits from glacial Lake Agassiz. The topography of this ecoregion is extremely flat, with sparse lakes and pothole wetlands. Tallgrass prairie was the dominant habitat prior to European settlement and has now been replaced with intensive agriculture. Agricultural production in the southern region consists of corn, soybeans, wheat, and sugar beets. The Sand Deltas and Beach Ridges (48b) ecoregion disrupts the flat topography of the Red River Valley. The beach ridges are parallel lines of sand and gravel that were formed by wave action of the contrasting shoreline levels of Lake Agassiz. The deltas consist of lenses of fine coarse sand and are blown into dunes (USGS, 2006).

The dominant soil associations in the Antelope Creek subwatersheds are the Fargo, Overly-Gardena, Hecla-Hamar-Arveson, Embden-Glyndon-Tiffany, and Galchutt-Fargo-Aberdeen. The Fargo association consists of mostly to nearly level topography, except for steeper elevations along streams and drainageways, with poorly drained, fine textured soils formed in clayey lacustrine sediments. The Overly-Gardena association consists of nearly level, moderately well drained; medium textured and moderately fine textured soils formed in silty lacustrine sediments. The Hecla-Hamar-Arveson association nearly level to undulating, moderately well drained to very poorly drained, coarse-textured to medium-textured soils formed in sandy and loamy lacustrine sediments. The Embden-Glyndon-Tiffany association is described as nearly level, to moderately well drained to poorly drained, moderately coarse textured and medium textured soils formed in loamy and silty lacustrine sediments; some are shallow over lime. The Galchutt-Fargo-Aberdeen association again is similar in topographical characteristics as the aforementioned associations, the soils of this association consist of somewhat poorly drained and poorly drained, with medium to moderately fine textured soils formed in silty and clayey lacustrine sediment, some soils are shallow over a sodic claypan subsoil (NRCS, 1975).

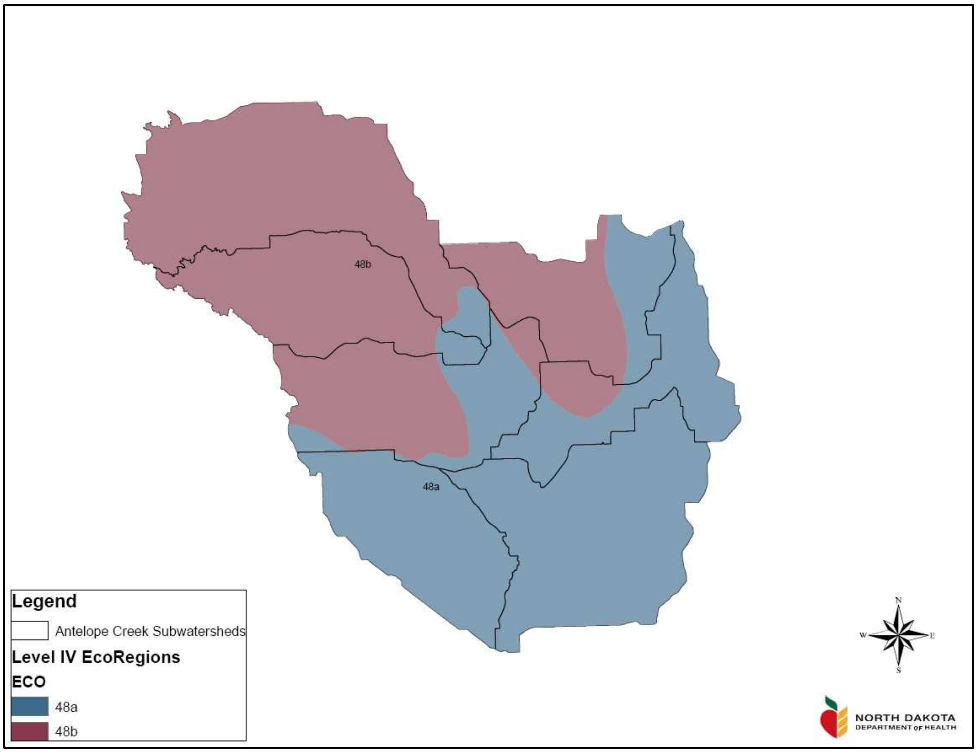

Figure 3. Level IV Ecoregions in the Antelope Creek Watershed.

1.3 Land Use

The dominant land uses in the Antelope Creek watershed is row crop agriculture. According to the 2006 National Agricultural Statistical Service (NASS) land survey data, approximately 86 percent of the land is active cropland, 5 percent in mid-density urban development, 9 percent is either wetlands, water, woods, barren, pasture/rangeland or in the conservation reserve program (CRP). The majority of the crops grown consist of soybeans, corn, spring wheat, alfalfa, sugar beets, sunflowers, and dry beans (Figure 4). Animal feeding operations and “hobby farms” are also present in the Antelope Creek watershed, but their number and location are unknown.

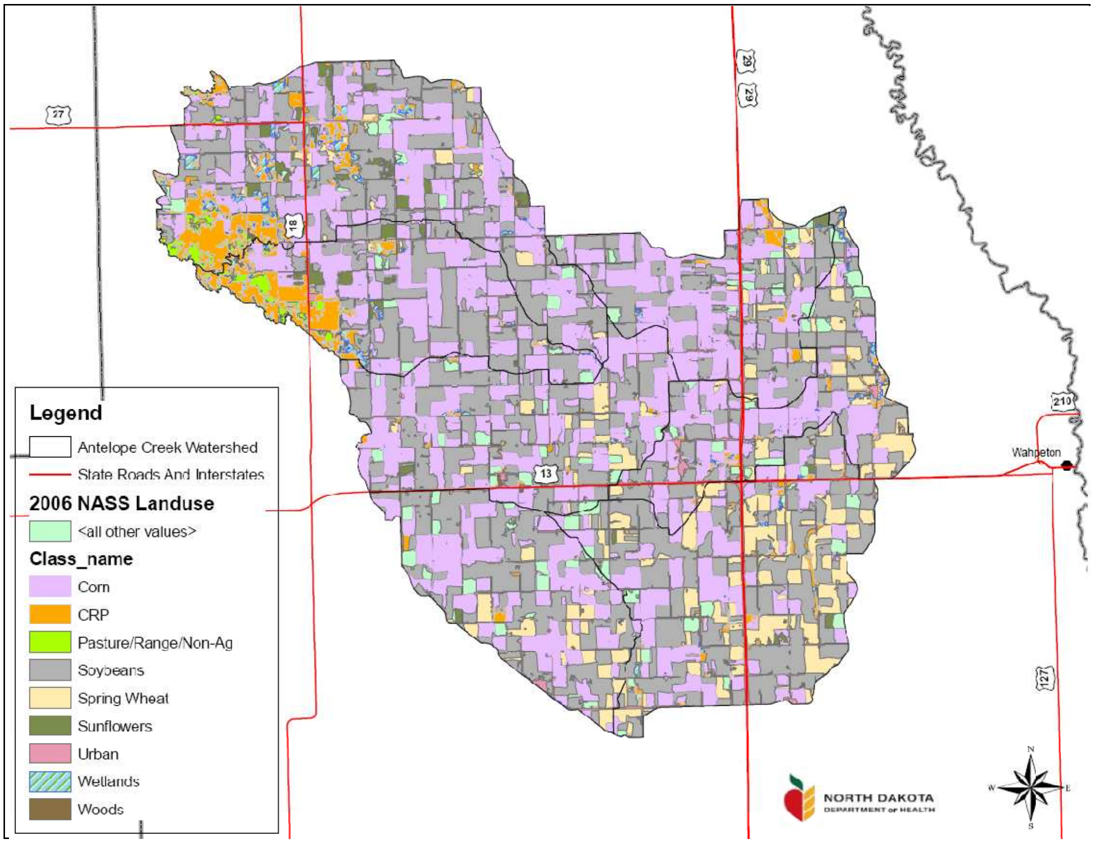

Figure 4. Land Use in the Antelope Creek Watershed (NASS, 2006).

1.4 Climate and Precipitation

Richland County has a subhumid climate characterized by warm summers with frequent hot days and occasional cool days. Average temperatures range from 12º F in winter to 60º F in summer. Precipitation occurs primarily during the warm period and is normally heavy in later spring and early summer. Total annual precipitation is about 20 inches. Figures 5 and 6 show the annual precipitation and average temperature for Wyndmere, ND located in the watershed and in Richland County from 1991-2008.

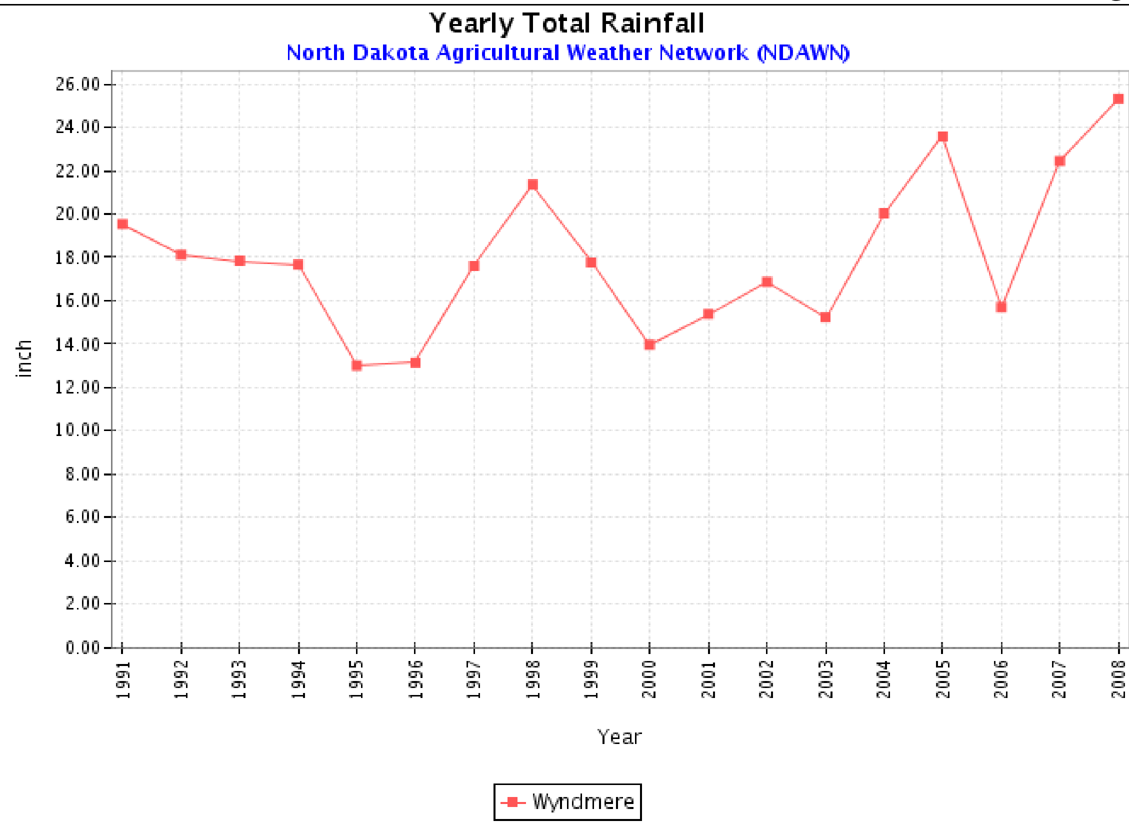

Figure 5. Annual Total Precipitation at Wyndmere, North Dakota from 1991-2008. North Dakota Agricultural Weather Network (NDAWN).

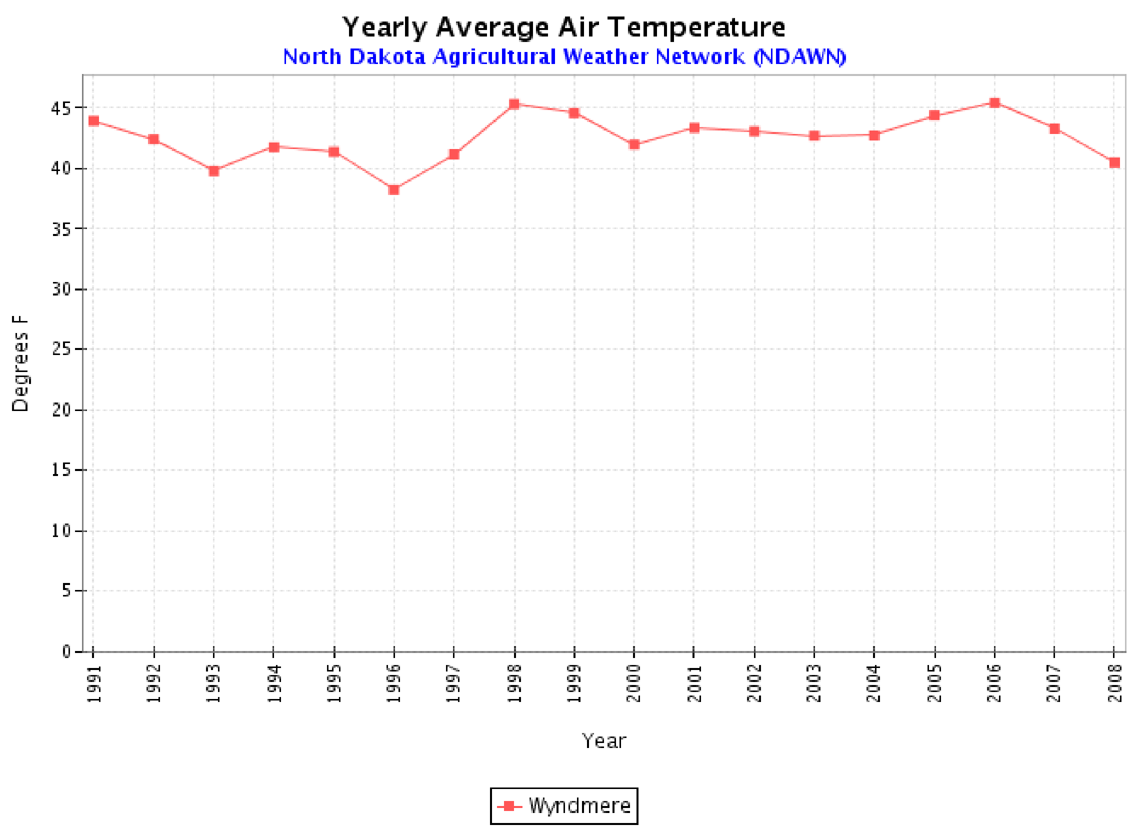

Figure 6. Annual Average Air Temperature at Wyndmere, North Dakota from 1991-2008. North Dakota Agricultural Weather Network (NDAWN).

1.5 Available Data

1.5.1 Fecal Coliform Bacteria Data

Fecal coliform bacteria samples were collected at one location within the TMDL listed watershed (Figure 7). The monitoring site, station ID 385232, located 0.5 mile north and 0.25 mile east of Dwight, ND on Richland County Road 10. It is also located one mile south (upstream) of the United States Geological Survey (USGS) gauging station 05052500. Site 385232 was monitored weekly, when flow conditions were present, during the recreation seasons of 2004 and 2006-2009 by the Richland County Soil Conservation District. The recreation season in North Dakota is May 1 to September 30.

Table 3 provides a summary of monthly fecal coliform geometric mean concentrations, the percentage of samples exceeding 400 CFU/100mL for each month and the recreational use assessment month. The geometric mean fecal coliform bacteria concentration and the percent of samples over 400 CFU/100ml was calculated for each month (May-September) using those samples collected during each month in 2004 and from 2006-2009.

Table 3. Summary of Fecal Coliform Data for Site 385232 Data Collected in 2004 and from 2006-2009.

Month	N	Geometric Mean Concentration (CFU/100mL)	Percentage of Samples Exceeding 400 CFU/100mL	Recreational Use Assessment
May	20	87	10%	Fully Supporting but Threatened
June	23	267	22%	Not Supporting
July	9	246	33%	Not Supporting
August	3	NA	NA	NA
September	3	NA	NA	NA

According to the data collected in 2004 and 2006 thru 2009 geometric mean and percent exceeded calculations determined that during the months of June and July Antelope Creek is not supporting recreational use due to fecal coliform bacteria impairment. Although the months of August and September did not have enough samples taken to calculate a geometric mean and percent exceeded they did indicate elevated concentrations of fecal coliform bacteria (Appendix A).

1.5.2 Hydraulic Discharge

A discharge record were constructed for the listed segment, based on historical discharge measurements collected by the USGS at gauging station (05052500) from 2003-2009. Site 385232 is located one mile south of the USGS gauge station (05052500).

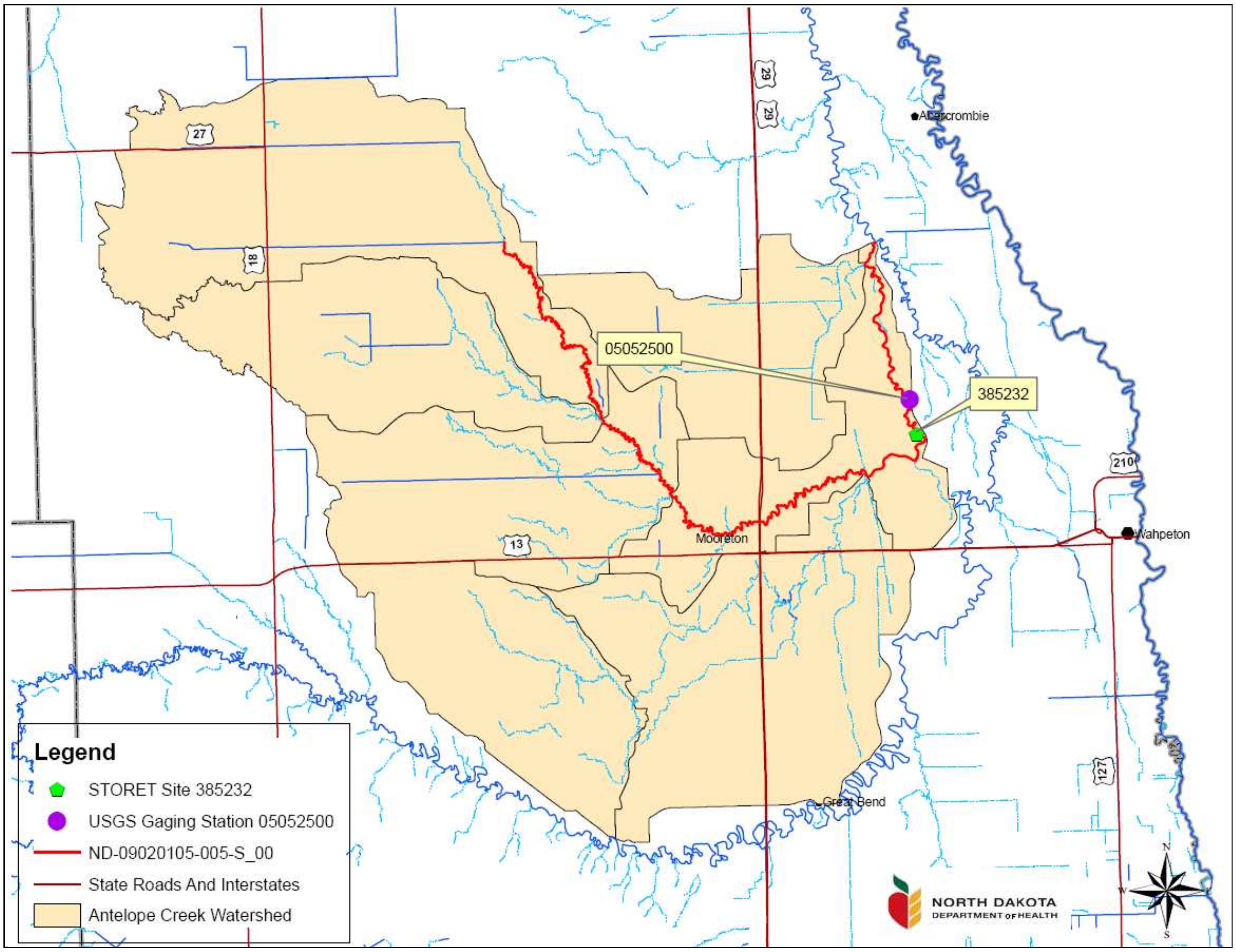

Figure 7. Fecal Coliform Bacteria Sample Site and USGS Gauge Station (05052500) on the TMDL Listed Segment of Antelope Creek.

2.0 WATER QUALITY STANDARDS

The Clean Water Act requires that Total Maximum Daily Loads (TMDLs) be developed for waters on a state's Section 303(d) list. A TMDL is defined as "the sum of the individual wasteload allocations for point sources and load allocations for non-point sources and natural background" such that the capacity of the waterbody to assimilate pollutant loadings is not exceeded. The purpose of a TMDL is to identify the pollutant load reductions or other actions that should be taken so that impaired waters will be able to attain water quality standards. TMDLs are required to be developed with seasonal variations and must include a margin of safety that addresses the uncertainty in the analysis. Separate TMDLs are required to address each pollutant or cause of impairment, which in this case is fecal coliform bacteria.

2.1 Narrative Water Quality Standards

The North Dakota Department of Health has set narrative water quality standards that apply to all surface waters in the State. The narrative general water quality standards are listed below (NDDoH, 2006).

- All waters of the State shall be free from substances attributable to municipal, industrial, or other discharges or agricultural practices in concentrations or combinations that are toxic or harmful to humans, animals, plants, or resident aquatic biota.

- No discharge of pollutants, which alone or in combination with other substances shall:

  a. Cause a public health hazard or injury to environmental resources;
  b. Impair existing or reasonable beneficial uses of the receiving water; or
  c. Directly or indirectly cause concentrations of pollutants to exceed applicable standards of the receiving waters.

In addition to the narrative standards, the NDDoH has set biological goal for all surface waters in the state. The goal states "the biological condition of surface waters shall be similar to that of sites or waterbodies determined by the department to be regional reference sites" (NDDoH, 2006).

2.2 Numeric Water Quality Standards

Antelope Creek is a Class III stream. The NDDoH definition of a Class III stream is shown below (NDDoH, 2006).

Class III- The quality of the waters in this class shall be suitable for agricultural and industrial uses. Streams in this class generally have low average flows with prolonged periods of no flow. During periods of no flow, they are of limited value for recreation and fish and aquatic biota. The quality of these waters must be maintained to protect secondary contact recreation uses (e.g., wading), fish and aquatic biota, and wildlife uses.

Numeric criteria have been developed for Class III streams for fecal coliform bacteria. Fecal coliform bacteria standards have been established and are shown in Table 4. The fecal coliform standard applies only during the recreation season from May 1 to September 30.

Table 4. North Dakota Fecal Coliform Bacteria Standards for Class III Streams.

Parameter	Standard	
	Geometric Mean[1]	Maximum[2]
Fecal Coliform Bacteria	200 CFU/100 mL	400 CFU/100 mL

[1] Expressed as a geometric mean of representative samples collected during any consecutive 30-day period.
[2] No more than 10 percent of samples collected during any consecutive 30-day period shall individually exceed the standard.

3.0 TMDL TARGETS

A TMDL target is the value that is measured to judge the success of the TMDL effort. TMDL targets must be based on state water quality standards, but can also include site specific values when no numeric criteria are specified in the standard. The following TMDL target for Antelope Creek is based on the NDDoH water quality standard for fecal coliform bacteria.

3.1 Antelope Creek Target Reductions in Fecal Coliform Concentrations

Antelope Creek is impaired because of fecal coliform bacteria. Antelope Creek is fully supporting, but threatened, for recreational beneficial uses because of fecal coliform bacteria counts exceeding the North Dakota water quality standard. The North Dakota water quality standard for fecal coliform bacteria is a geometric mean concentration of 200 CFU/100 mL during the recreation season from May 1 to September 30. Thus, the TMDL target for this report is 200 CFU/100 mL. In addition, no more than ten percent of samples collected for fecal coliform should exceed 400 CFU/100 mL. While the standard is intended to be expressed as the 30-day geometric mean, the target is based on the 200 CFU/100 mL geometric mean standard. Expressing the target in this way will ensure the TMDL will result in both components of the standard being met and recreational uses are restored.

4.0 SIGNIFICANT SOURCES

4.1 Point Source Pollution Sources

Within the Antelope Creek watershed, there is a municipal point source located in Dwight, ND. This facility is permitted through the North Dakota Pollutant Discharge Elimination System (NDPDES) Program. The Dwight facility provides for total containment and has not discharged into Antelope Creek, therefore no allocation will be provided to the city in the WLA.

There are eight permitted animal feeding operations (AFOs) in the TMDL watershed of Antelope Creek. The NDDOH has permitted two large (1,000 + animal units (AUs)) AFOs to operate. Three small (0-300 AUs) and three medium (301-999 AUs) AFOs are currently in the permitting process. All eight AFOs are zero discharge facilities and are not deemed a significant source of fecal coliform loadings to Antelope Creek.

4.2 Non-point Source Pollution Sources

The TMDL listed segment on Antelope Creek is experiencing fecal coliform bacteria pollution from non-point sources in the watershed. Livestock production is not the dominant agricultural practice in the watershed but unpermitted animal feeding operations (AFOs) and “hobby farms” with fewer than 100 animals in proximity to Antelope Creek are common along the TMDL listed segment. The southeast section of North Dakota typically experiences long duration or intense precipitation during the early summer months. These storms can cause overland flooding and rising river levels it is likely that, the close proximity of these AFOs and “hobby farms” contributes fecal coliform bacteria to Antelope Creek.

This assessment is also supported by the load duration curve analysis (Section 5.3) which shows all of the exceedences of the fecal coliform bacteria standard occurring during high and moderate flows. Further examination of these data show that these exceedences all occurred during high and moderate flow events cause by intense spring and summer rain storms.

Wildlife may also contribute to the fecal coliform bacteria found in the water quality samples, but most likely in a lower concentration. Wildlife are nomadic with fewer numbers concentrating in a specific area, thus decreasing the probability of their contribution of fecal matter in significant quantities.

Septic system failure might contribute to the fecal coliform bacteria in the water quality samples. Failures can occur for several reasons, although the most common reason is improper maintenance (e.g. age, inadequate pumping). Other reasons for failure include improper installation, location, and choice of system. Harmful household chemicals can also cause failure by killing the bacteria that digest the waste. While the number of systems that are not functioning properly is unknown, it is estimated that 28 percent of the systems in North Dakota are failing (USEPA, 2002).

5.0 TECHNICAL ANALYSIS

In TMDL development, the goal is to define the linkage between the water quality target and the identified source or sources of the pollutant (i.e. fecal coliform bacteria) to determine the load reduction needed to meet the TMDL target. To determine the cause and effect relationship between the water quality target and the identified source, the “load duration curve” methodology was used.

The loading capacity or total maximum daily load (TMDL) is the amount of a pollutant (e.g. fecal coliform bacteria) a waterbody can receive and still meet and maintain water quality standards and beneficial uses. The following technical analysis addresses the fecal coliform bacteria reductions necessary to achieve the water quality standards target for fecal coliform bacteria of 200 CFU/100 mL with a margin of safety.

5.1 Mean Daily Stream Flow

In southeastern North Dakota, rain events are variable generally occurring during the months of April through August. Rain events can be sporadic and heavy or light, occurring over a short duration. Precipitation events of large magnitude, occurring at a faster rate than absorption, contribute to high runoff events. These events are represented by runoff in the high flow regime. The medium flow regime is represented by runoff that contributes to the stream over a longer duration. The low flow regime is characteristic of drought or precipitation events of small magnitude and do not contribute to runoff.

Flows used in the load duration curve analysis based on the mean daily flow record collected at the United States Geological Survey (USGS) gauge site (05052500) located at Dwight, ND from 2003 through 2009. Since the location of the USGS gauge site and water quality monitoring site (385232) were within a mile distance from one another no adjustment in flow was made.

5.2 Flow Duration Curve Analysis

The flow duration curve serves as the foundation for the load duration curve used in the TMDL. Flow duration curve analysis looks at the cumulative frequency of historic flow data over a specified time period. A flow duration curve relates flow (expressed as mean daily discharge) to the percent of time those mean daily flow values have been met or exceeded. The use of *"percent of time exceeded"* (i.e., duration) provides a uniform scale ranging from 0 to 100 percent, thus accounting for the full range of stream flows. Low flows are exceeded most of the time, while flood flows are exceeded infrequently (USEPA, 2007).

A basic flow duration curve runs from high to low (0 to 100 percent) along the x-axis with the corresponding flow value on the y-axis (Figure 8). Using this approach, flow duration intervals are expressed as a percentage, with zero corresponding to the highest flows in the record (i.e., flood conditions) and 100 to the lowest flows in the record (i.e., drought). Therefore, as depicted in Figure 8, a flow duration interval of twenty five (25) percent, associated with a stream flow of 18 cfs, implies that 25 percent of all observed mean daily discharge values equal or exceed 18 cfs.

Once the flow duration curve is developed for the stream site, flow duration intervals can be defined which can be used as a general indicator of hydrologic condition (i.e. wet vs dry conditions and to what degree). These intervals (or zones) provide additional insight about conditions and patterns associated with the impairment (fecal coliform bacteria in this case) (USEPA, 2007). As depicted in Figure 8, the flow duration curve was divided into four zones, one representing high flows (10 percent), another for moist condition (10-25 percent), one for dry condition (25-43 percent) and one for low flows (43-50 percent). Based on the flow duration curve analysis, no flow occurred 50 percent of the time (50-100 percent). These flows intervals were defined by examining the range of flows for the site for the period of record and then by looking for natural breaks in the flow record based on the flow duration curve plot (Figure 8). A secondary factor in determining the flow intervals used in the analysis is the number of fecal coliform observations available for each flow interval.

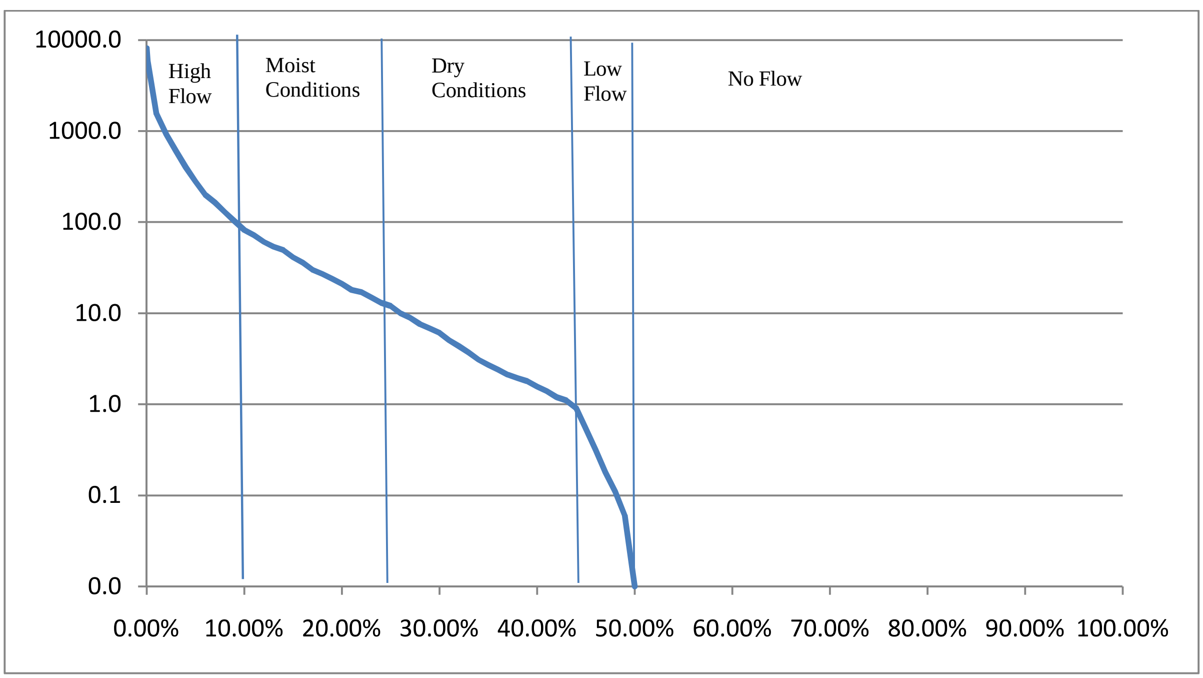

Figure 8. Flow Duration Curve for Antelope Creek Monitoring Station 385232 Located One Mile South of the USGS Station 05052500 at Dwight, North Dakota.

5.3 Load Duration Analysis

An important factor in determining NPS pollution loads is variability in stream flows and loads associated with high and low flow. To better correlate the relationship between the pollutant of concern and hydrology of the 303(d) listed segment, a load duration curve was developed for the TMDL listed segment in the Antelope Creek watershed. The load duration curve was derived using the 200 CFU/100mL State water quality standard and the flows generated as described in Sections 5.1 and 5.2.

Observed in-stream total fecal coliform bacteria data obtained from monitoring site 385232 from 2004 and 2006 through 2009 (Appendix A) were converted to a pollutant load by multiplying total fecal coliform bacteria concentrations by the mean daily flow and a conversion factor. These loads are plotted against the percent exceeded of the flow on the day of sample collection (Figure 9). Points plotted above the 200 CFU/100 mL target curve exceed the water quality target. Points plotted below the curve are meeting the water quality target of 200 CFU/100 mL.

For each flow interval or zone, a regression relationship was developed between the samples which occur above the TMDL target (200 CFU/100 mL) curve and the corresponding percent exceeded flow. The load duration curve for site 385232 depicting a regression relationship for each flow interval are provided in Figure 9. As there were no fecal coliform bacteria concentrations above the TMDL target in the low flow regime for this site, a regression relationship and existing load could not be calculated for this flow regime.

The regression lines for the high, moist condition, and dry condition flows were then used with the midpoint of the percent exceeded flow for that interval to calculate the existing total fecal coliform bacteria load for that flow interval. For example, in the example provided in Figure 9, the regression relationship between observed fecal coliform bacteria loading and percent exceeded flow for the high flow (0-10 percent), moist condition, and dry condition flow interval are:

Fecal coliform load (expressed as 10^7 CFUs/day) = antilog (Intercept + (Slope*Percent Exceeded Flow))

Where the midpoint of the high flow interval from 0 to 10 percent is 5.01 percent, the existing fecal coliform load is:

Fecal coliform load (10^7 CFUs/day) = antilog (6.86 + (-21.89*0.0501))
= 585,545

Where the midpoint of the moist condition interval from 10 to 25 percent is 17.5 percent, the existing fecal coliform load is:

Fecal coliform load (10^7 CFUs/day) = antilog (6.38 + (-11.81*0.175))
= 20,768

Where the midpoint of the dry condition interval from 25 to 43 percent is 34 percent, the existing fecal coliform load is:

Fecal coliform load (10^7 CFUs/day) = antilog (4.99 + (-4.60*0.34))
= 2,695

The midpoint for the flow intervals is also used to estimate the TMDL target load. In the case of the previous examples, the TMDL target load for the midpoints or 5.01, 17.5, and 34 percent exceeded flow derived from the 200 CFU/100 mL TMDL target curves are 136,833 x 10^7 CFUs/day, 13,702 x 10^7 CFUs/day, and 1,505 x 10^7 CFUs/day, respectively.

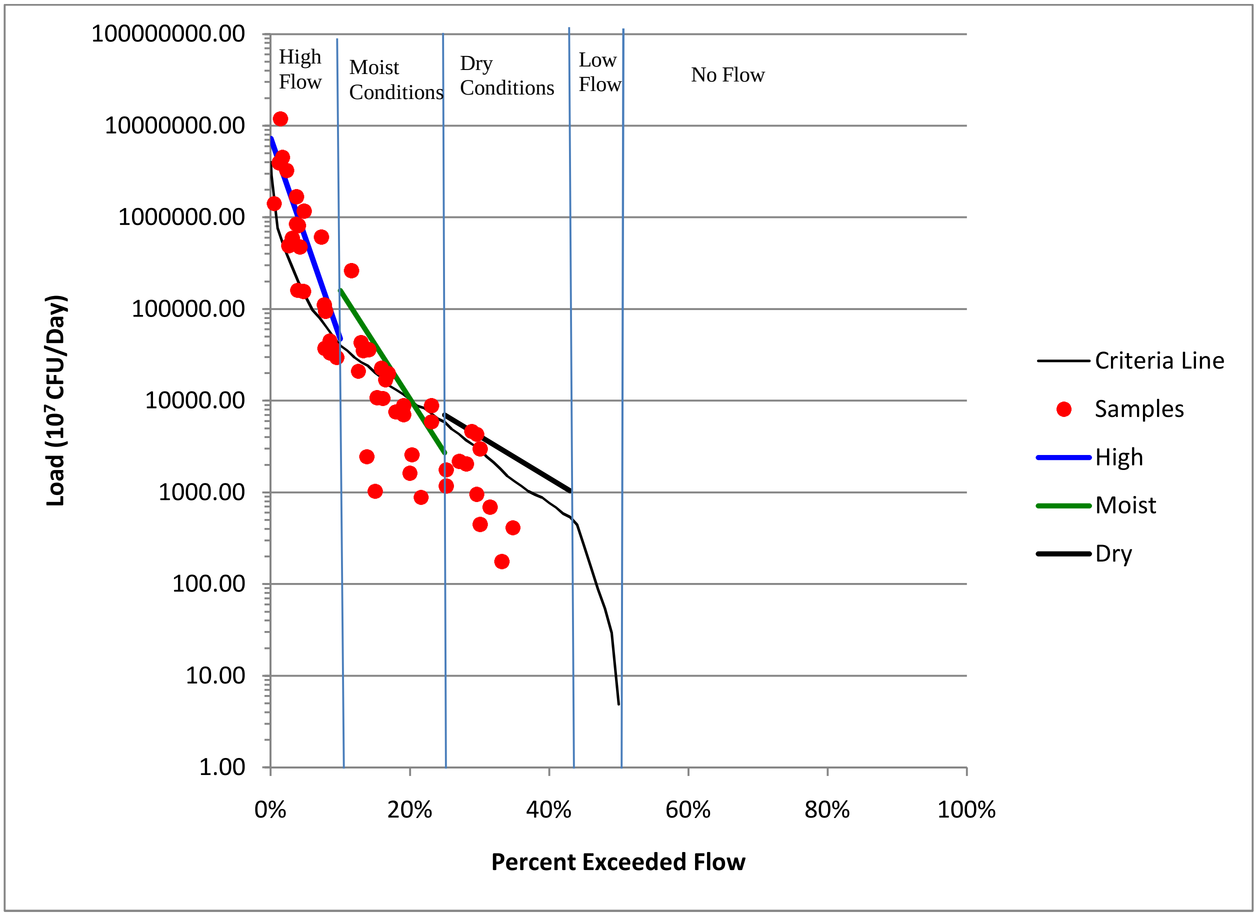

Figure 9. Load Duration Curve for Antelope Creek Monitoring Station 385232; Located one mile south of the USGS Station 05052500 at Dwight, ND (The curve reflects flows collected from 2003-2009).

5.4 Loading Sources

The load reductions needed for the Antelope Creek fecal coliform bacteria TMDL can generally be allotted to non-point sources. Based on the data available, the general focus of BMPs and load reductions for the listed waterbody should be on unpermitted animal feeding operations and "hobby farms" adjacent to or in close proximity to Antelope Creek.

Significant sources of total fecal coliform loading were defined as non-point source pollution originating from livestock. One of the more important concerns regarding non-point sources is variability in stream flows. Variable stream flows often cause different source areas and loading mechanisms to dominate (Cleland, 2003). As previously described, three flow regimes (i.e., High Flow and Moist and Dry Conditions) were selected to represent the hydrology of the listed segment when applicable (Figure 7). The three flow regimes were used for site 385232 because samples indicated exceedences of the water quality standard during periods of high and moderate flows.

By relating runoff characteristics to each flow regime one can infer which sources are most likely to contribute to fecal coliform loading. Animals grazing in the riparian area contribute fecal coliform bacteria by depositing manure where it has an immediate impact on water quality. Due to the close proximity of manure to the stream or by direct deposition in the stream, riparian grazing impacts water quality at high flow or under moist and dry conditions (Table 5). In contrast, intensive grazing of livestock in the upland and not in the riparian area has a high potential to impact water quality at high flows and under moist conditions impact at moderate flows (Table 5). Exclusion of livestock from the riparian area eliminates the potential of direct manure deposit and therefore is considered to be of high importance at all flows. However, intensive grazing in the upland creates the potential for manure accumulation and availability for runoff at high flows and a high potential for total fecal coliform bacteria contamination.

Table 5. Non-point Sources of Pollution and Their Potential to Pollute at a Given Flow Regime.

Non-Point Sources	Flow Regime		
	High Flow	Moist Conditions	Dry Conditions
Riparian Area Grazing (Livestock)	H	H	H
Animal Feeding Operations	H	M	L
Manure Application to Crop and Range Land	H	M	L
Intensive Upland Grazing (Livestock)	H	M	L

Note: Potential importance of non-point source area to contribute fecal coliform bacteria loads under a given flow regime. (H: High; M: Medium; L: Low)

6.0 MARGIN OF SAFETY AND SEASONALITY

6.1 Margin of Safety

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency (EPA) regulations require that "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality." The margin of safety (MOS) can be either incorporated into conservative assumptions used to develop the TMDL (implicit) or added to a separate component of the TMDL (explicit).

To account for the uncertainty associated with known sources and the load reductions necessary to reach the TMDL target of 200 CFU/100 mL, a ten percent explicit margin of safety was used for this TMDL. The MOS was calculated as ten percent of the TMDL. In other words ten percent of the TMDL is set aside from the load allocation as a MOS.

The ten percent MOS was derived by taking the difference between the points on the load duration curve using the 200 CFU/100 mL standard and the curve using the 180 CFU/100 mL.

6.2 Seasonality

Section 303(d)(1)(C) of the Clean Water Act and associated regulations require that a TMDL be established with seasonal variations. The Antelope Creek TMDL addresses seasonality because the flow duration curve was developed using 6 years of USGS gauge data encompassing all 12 months of the year. Additionally, the water quality standard is seasonally based on the recreation season from May 1 to September 30 and controls will be designed to reduce fecal coliform bacteria loads during the seasons covered by the standard.

7.0 TMDL

Table 6 provides an outline of the critical elements of the waterbody specific fecal coliform bacteria TMDL located within the Antelope Creek watershed. A TMDL for waterbody ND-09020105-005-S_00 is represented in Table 7. The TMDL provides a summary of average daily loads necessary to meet the water quality target (i.e. TMDL). The TMDL summary provides an estimate of the existing daily load, an estimate of the average daily loads' necessary to meet the water quality target (i.e. TMDL load). This TMDL load includes a load allocation from known non-point sources and a 10 percent margin of safety. It should be noted that the TMDL loads, load allocations, and the MOS are estimated based on available data and reasonable assumptions and are to be used as a guide for implementation. The actual reduction needed to meet the applicable water quality standards may be higher or lower depending on the results of future monitoring.

Table 6. TMDL Summary for Antelope Creek.

Category	Description	Explanation
Beneficial Use Impaired	Recreation	Contact Recreation (i.e. swimming, fishing)
Pollutant	Fecal Coliform Bacteria	See Section 2.1
TMDL Target	200 CFU/100 ml	Based on North Dakota water quality standards
Significant Sources	Non-point Sources	No contributing Point Sources in Subwatershed
Margin of Safety (MOS)	Explicit	10%

TMDL = LC = WLA + LA + MOS

where

LC = loading capacity, or the greatest loading a waterbody can receive without violating water quality standards;

WLA = wasteload allocation, or the portion of the TMDL allocated to existing or future point sources;

LA = load allocation, or the portion of the TMDL allocated to existing or future non-point sources;

MOS = margin of safety, or an accounting of the uncertainty about the relationship between pollutant loads and receiving water quality. The margin of safety can be provided implicitly through analytical assumptions or explicitly by reserving a portion of the loading capacity.

Table 7. Fecal Coliform Bacteria TMDL (10^7 CFU/day) for the Antelope Creek Waterbody ND-09020105-005-S_00 as represented by Site 385232.

		Flow Regime		
	High Flow	Moist Conditions	Dry Conditions	Low Flow
Existing Load	585,544	20,768	2,695	No load reduction necessary
TMDL	136,833	13,702	1,505	
WLA	0	0	0	
LA	123,150	12,332	1,355	
MOS	13,683	1,370	150	

8.0 ALLOCATION

There are no known point sources impacting the watershed. Therefore the entire total fecal coliform load for this TMDL was allocated to non-point sources in the watershed. The entire non-point source load is allocated as a single load because there is not enough detailed source data to allocate the load to individual uses (e.g., animal feeding, septic systems, riparian grazing, waste management). To achieve the TMDL targets identified in the report, it will require the wide spread support and voluntary participation of landowners and residents in the immediate watershed as well as those living upstream. The TMDLs described in this report are a plan to improve water quality by implementing best management practices through non-regulatory approaches. “Best management practices” (BMPs) are methods, measures, or practices that are determined to be a reasonable and cost effective means for a land owner to meet non-point source pollution control needs,” (USEPA, 2001). This TMDL plan is put forth as a recommendation for what needs to be accomplished for Antelope Creek and associated watersheds to restore and maintain its recreational uses. Water quality monitoring should continue, in order to measure BMP effectiveness and determine through adaptive management if loading allocation recommendations need to be adjusted.

Non-point source pollution is the sole contributor to elevated total fecal coliform bacteria levels in Antelope Creek. The fecal coliform samples and load duration curve analysis of the impaired reach identified the high and moderate flow regimes as the time of fecal coliform bacteria exceedences of the 200 CFU/100 mL target. To reduce NPS pollution for the high and moderate flow regimes, specific BMPs are described in Section 8.1 that will mitigate the effects of total fecal coliform bacteria loading to the impaired reach.

Table 8. Management Practices and Flow Regimes Affected by Implementation of BMPs.

Management Practice	Flow Regime and Expected Reduction		
	High Flow-70%	Moderate Flow-80%	Low Flow-74%
Livestock Exclusion From Riparian Area	X	X	X
Water Well and Tank Development	X	X	X
Prescribed Grazing	X	X	X
Waste Management System	X	X	
Vegetative Filter Strip		X	
Septic System Repair		X	X

Controlling non-point sources is an immense undertaking requiring extensive financial and technical support. Provided that technical/financial assistance is available to stakeholders, these BMPs have the potential to significantly reduce total fecal coliform loading to Antelope Creek. The following describe in detail those BMPs that will reduce total fecal coliform bacteria levels in Antelope Creek.

8.1 Livestock Management Recommendations

Livestock management BMPs are designed to promote healthy water quality and riparian areas through management of livestock and associated grazing land. Fecal matter from livestock, erosion from poorly managed grazing, land and riparian areas can be a significant source of fecal coliform bacteria loading to surface water. Precipitation, plant cover, number of animals, and soils are factors that affect the amount of bacteria delivered to a waterbody because of livestock. These specific BMPs are known to reduce non-point source pollution from livestock. These BMPs include:

<u>Livestock exclusion from riparian areas</u>- This practice is established to remove livestock from grazing riparian areas and watering in the stream. Livestock exclusion is accomplished through fencing. A reduction in stream bank erosion can be expected by minimizing or eliminating hoof trampling. A stable stream bank will support vegetation that will hold banks in place and serve a secondary function as a filter from non-point source runoff. Added vegetation will create aquatic habitat and shading for macroinvertebrates and fish. Direct deposit of fecal matter into the stream and stream banks will be eliminated as a result of livestock exclusion by fencing.

<u>Water well and tank development</u>- Fencing animals from stream access requires and alternative water source. Installing water wells and tanks satisfies this need. Installing water tanks provides a quality water source and keeps animals from wading and defecating in streams. This will reduce the probability of pathogenic infections to livestock and the public.

Prescribed grazing- This practice is used to increase ground cover and ground stability by rotating livestock throughout multiple fields. Grazing with a specified rotation minimizes overgrazing and resulting erosion. The Natural Resource Conservation Service (NRCS) recommends grazing systems to improve and maintain water quality and quantity. Duration, intensity, frequency, and season of grazing can be managed to enhance vegetation cover and litter, resulting in reduced runoff, improved infiltration, increased quantity of soil water for plant growth, and better manure distribution and increased rate of decomposition, (NRCS, 1998). In a study by Tiedemann et al. (1998), as presented by USEPA (1993), the effects of four grazing strategies on bacteria levels in thirteen watersheds in Oregon were studied during the summer of 1984. Results of the study (Table 9) showed that when livestock are managed at a stocking rate of 19 acres per animal unit month, with water developments and fencing, bacteria levels were reduced significantly.

Waste management system- Waste management systems can be effective in controlling up to 90 percent of fecal coliform bacteria loading originating from confined animal feeding areas (Table 10). A waste management system is made up of various components designed to control non-point source pollution from concentrated animal feeding operations (CAFOs) and animal feeding operations (AFOs). Diverting clean water from the feeding area and containing dirty water from the feeding area in a pond are typical practices of a waste management system. Manure handling and application of manure is designed to be adaptive to environmental, soil, and plant conditions to minimize the probability of contamination of surface water.

Table 9. Bacterial Water Quality Response to Four Grazing Strategies (Tiedemann et al., 1988).

Grazing Strategy		Geometric Mean Fecal Coliform Count
Strategy A:	Ungrazed	40/L
Strategy B:	Grazing without management for livestock distribution; 20.3 ac/AUM.	150/L
Strategy C:	Grazing with management for livestock distribution: fencing and water developments; 19.0 ac/AUM	90/L
Strategy D:	Intensive grazing management, including practices to attain uniform livestock distribution and improve forage production with cultural practices such as seeding, fertilizing, and forest thinning; 6.9 ac/AUM	950/L

8.2 Other Recommendations

Vegetative filter strip- Vegetated filter strips are used to reduce the amount of sediment, particulate organics, dissolved contaminants, nutrients, and in the case of this TMDL, fecal coliform bacteria to streams. The effectiveness of filter strips and other BMPs in removing fecal coliform bacteria is quite successful. Results from a study by Pennsylvania State University (1992a) as presented by USEPA (1993) (Table 10), suggest that vegetative filter strips are capable of removing up to 55 percent of fecal coliform loading to rivers and streams (Table 10). The ability of the filter strip to remove contaminants is dependent on field slope, filter strip slope, erosion rate, amount and particulate size distribution of sediment delivered to the filter strip, density and height of vegetation, and runoff volume associated with erosion producing events (NRCS, 2001).

Table 10. Relative Gross Effectiveness[a] of Confined Livestock Control Measures (Pennsylvania State University, 1992a).

Practice[b] Category	Runoff[c] Volume	Total[d] Phosphorus (%)	Total[d] Nitrogen (%)	Sediment (%)	Fecal Coliform (%)
Animal Waste System[e]	-	90	80	60	85
Diversion System[f]	-	70	45	NA	NA
Filter Strips[g]	-	85	NA	60	55
Terrace System	-	85	55	80	NA
Containment Structures[h]	-	60	65	70	90

NA = Not Available.
a Actual effectiveness depends on site-specific conditions. Values are not cumulative between practice categories.
b Each category includes several specific types of practices.
c - = reduction; + = increase; 0 = no change in surface runoff.
d Total phosphorus includes total and dissolved phosphorus; total nitrogen includes organic-N, ammonia-N, and nitrate-N.
e Includes methods for collecting, storing, and disposing of runoff and process-generated wastewater.
f Specific practices include diversion of uncontaminated water from confinement facilities.
g Includes all practices that reduce contaminant losses using vegetative control measures.
h Includes such practices as waste storage ponds, waste storage structures, waste treatment lagoons.

<u>Septic System</u> – Septic systems provide an economically feasible way of disposing of household wastes where other means of waste treatment are unavailable (e.g., public or private treatment facilities). The basis for most septic systems involves the treatment and distribution of household wastes through a series of steps involving the following:

1. A sewer line connecting the house to a septic tank
2. A septic tank that allows solids to settle out of the effluent
3. A distribution system that dispenses the effluent to a leach field
4. A leaching system that allows the effluent to enter the soil

Septic system failure occurs when one or more components of the septic system do not work properly and untreated waste or wastewater leaves the system. Wastes may pond in the leach field and ultimately run off directly into nearby streams or percolate into groundwater. Untreated septic system waste is a potential source of nutrients (nitrogen and phosphorus), organic matter, suspended solids, and fecal coliform bacteria. Land application of septic system sludge, although unlikely, may also be a source of contamination.

Septic system failure can occur for several reasons, although the most common reason is improper maintenance (e.g. age, inadequate pumping). Other reasons for failure include improper installation, location, and choice of system. Harmful household chemicals can also cause failure by killing the bacteria that digest the waste. While the number of systems that are not functioning properly is unknown, it is estimated that 28 percent of the systems in North Dakota are failing (USEPA, 2002).

9.0 PUBLIC PARTICIPATION

To satisfy the public participation requirement of this TMDL, a hard copy of the TMDL for Antelope Creek and a request for comment will be mailed to participating agencies, partners, and to those who request a copy. Those included in the mailing of a hard copy are as follows:

- Richland County Soil Conservation District;
- Richland County Water Resource Board;
- Natural Resource Conservation Service (State Office); and
- U.S. Environmental Protection Agency, Region VIII

In addition to mailing copies of this TMDL for Antelope Creek to interested parties, the TMDL will be posted on the North Dakota Department of Health, Division of Water Quality web site at http://www.ndhealth.gov./WQ/SW/Z2 TMDL/TMDLs Under PublicComment/B Under Public Commment.html . A 30 day public notice soliciting comment and participation was also published in the following newspapers:

- Fargo Forum; and
- The Daily News (Richland County).

10.0 MONITORING

As stated previously, it should be noted that the TMDL loads, load allocations, and the MOS are estimated based on available data and reasonable assumptions and are to be used as a guide for implementation. The actual reduction needed to meet the applicable water quality standards may be higher or lower depending on the results of future monitoring.

To insure that the best management practices (BMPs) and technical assistance that are implemented as part of the Section 319 Antelope Creek Watershed Restoration Project are successful in reducing fecal coliform bacteria loadings to levels prescribed in this TMDL, water quality monitoring is being conducted in accordance with an approved Quality Assurance Project Plan (QAPP). As prescribed in the QAPP (NDDoH, 2004), weekly monitoring is being conducted at two sites for fecal coliform. Sampling began in May 2006 and will continue through September 2010.

11.0 TMDL IMPLEMENTATION STRATEGY

In response to the Antelope Creek Watershed Assessment and in anticipation of this completed TMDL, local sponsors successfully applied for and received Section 319 funding for the Antelope Creek Watershed Restoration Project. Beginning in May 2006, local sponsors have been providing technical assistance and implementing BMPs designed to reduce fecal bacteria loadings and to help restore the beneficial uses of Antelope Creek (i.e., recreation). As the watershed restoration project progresses, water quality data are collected to monitor and track the effects of BMP implementation as well as to judge overall success of the project in reducing fecal coliform bacteria loadings. A QAPP (NDDoH, 2005) has also been developed as part of this watershed restoration project that details the how, when and where monitoring will be conducted to gather the data needed to document success in meeting the TMDL implementation goal(s). As the data are gathered and analyzed, watershed restoration tasks will be adapted, if necessary, to place BMPs where they will have the greatest benefit to water quality and in meeting the TMDL goal(s).

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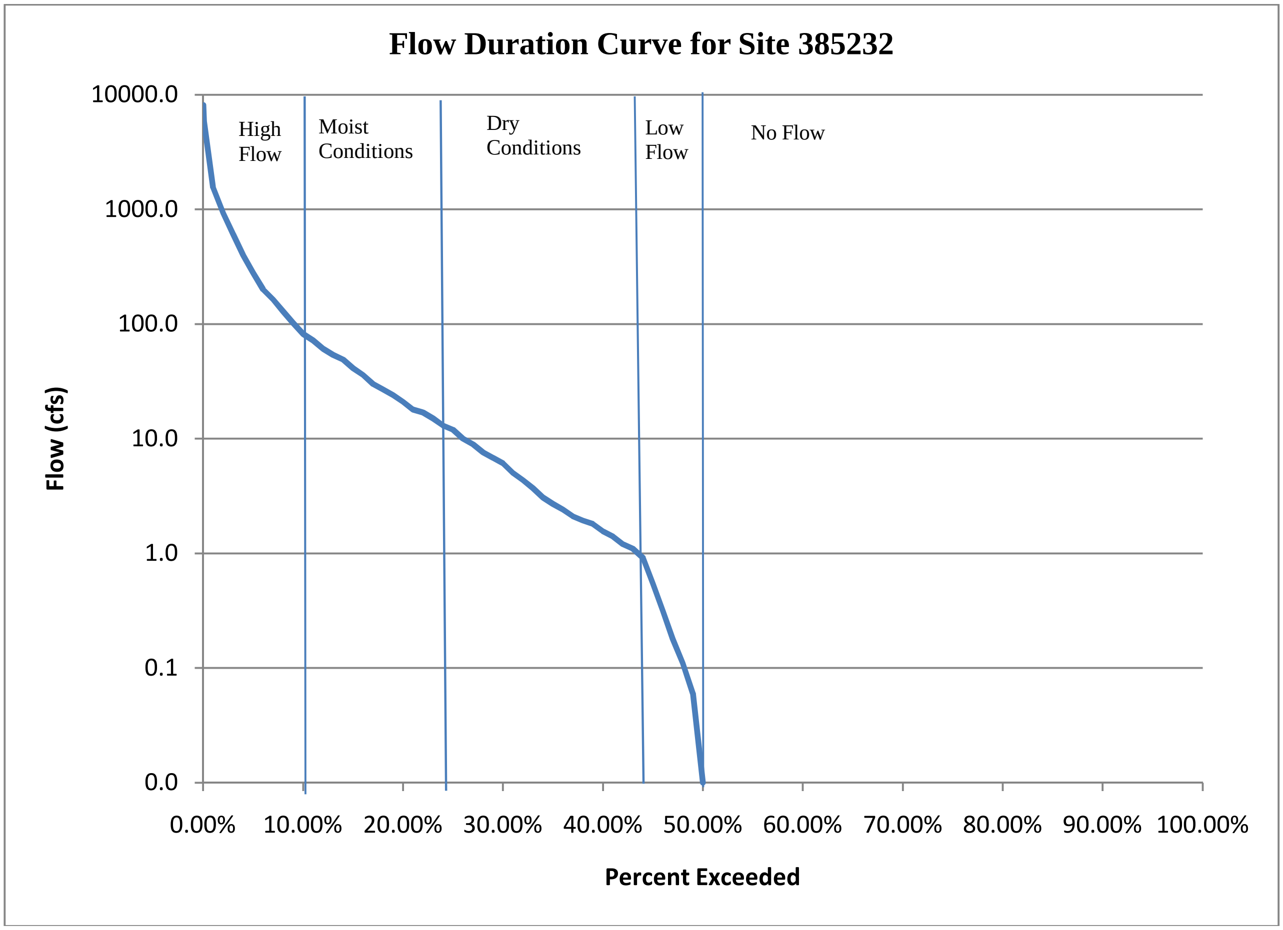
Appendix A
Fecal Coliform Bacteria Data Collected for Site 385232
(2004 and 2006-2009)

STORET	Collection Date	CFU/100 mL	STORET	Collection Date	CFU/100 mL
385232	01-Jun-04	1070	385232	25-Jun-07	110
385232	03-Jun-04	200	385232	02-Jul-07	160
385232	07-Jun-04	140	385232	06-May-08	20
385232	09-Jun-04	110	385232	14-May-08	40
385232	14-Jun-04	270	385232	19-May-08	60
385232	17-Jun-04	20	385232	04-Jun-08	150
385232	07-Jul-04	210	385232	10-Jun-08	290
385232	13-Jul-04	120	385232	16-Jun-08	150
385232	22-Jul-04	60	385232	18-Jun-08	270
385232	27-Sep-04	260	385232	23-Jun-08	100
385232	01-May-06	110	385232	25-Jun-08	270
385232	03-May-06	500	385232	01-Jul-08	60
385232	08-May-06	300	385232	12-Aug-08	1600
385232	11-May-06	130	385232	13-Aug-08	1600
385232	16-May-06	150	385232	14-Oct-08	360
385232	18-May-06	250	385232	22-Apr-09	10
385232	23-May-06	60	385232	28-Apr-09	5
385232	30-May-06	30	385232	05-May-09	10
385232	20-Sep-06	70	385232	12-May-09	30
385232	26-Sep-06	70	385232	19-May-09	110
385232	01-May-07	20	385232	26-May-09	320
385232	07-May-07	400	385232	02-Jun-09	240
385232	09-May-07	160	385232	08-Jun-09	200
385232	16-May-07	50	385232	16-Jun-09	110
385232	31-May-07	120	385232	23-Jun-09	1600
385232	04-Jun-07	200	385232	01-Jul-09	800
385232	06-Jun-07	3600	385232	08-Jul-09	110
385232	12-Jun-07	320	385232	15-Jul-09	1600
385232	14-Jun-07	1600	385232	20-Jul-09	1600
385232	19-Jun-07	260	385232	18-Aug-09	1600
385232	21-Jun-07	830			

Appendix B
Flow Duration Curve for Site 385232



Flow Duration Curve for Site 385232
10000.0
1000.0
100.0
10.0
1.0
0.1
0.0
Flow (cfs)
High
Flow
Moist
Conditions
Dry
Conditions
Low
Flow
No Flow
0.00%
10.00%
20.00%
30.00%
40.00%
50.00%
60.00%
70.00%
80.00%
90.00%
100.00%
Percent Exceeded

Appendix C
Load Duration Curve, Estimated Loads, TMDL Targets, and Percentage of Reduction Required for Site 385232

	Load (10^7 CFUs/Day)				Load (10^7 CFUs/Period)		
	Median Percentile	Existing	TMDL	Days	Existing	TMDL	Percent Reduction
High	5.01%	585544.86	136833.32	36.46	21351014.98	4989421.82	76.63%
Moist	17.50%	20768.30	13702.63	54.75	1137064.56	750219.17	34.02%
Dry	34.00%	2695.19	1505.33	65.70	177073.99	98900.32	44.15%
			Total	157	22665154	5838541	74.24%

385232 Antelope Creek near Dwight, ND